Effect of Start-Up Conditions on Nitrification Rates: Ammonia Concentrations and Salinity

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Abstract

Biological filters are commonly used in recirculating aquaculture systems (RAS) to oxidize ammonia to nitrite and nitrite to nitrate. The start-up period will take from a few days to several weeks depending on the source of water (fresh or marine), temperature (Nijhof and Bovendeur, 1990), and the use of seeding material (Carmignani and Bennett, 1977; Bowen and Turner, 1981). Many authors observed higher nitrification rates and shorter start-up periods for fresh water biofilters. Nijhof and Bovendeur (1990) proposed to adapt fresh water biofilters to higher salinities in order to minimize start-up periods for sea-water; in contrast, Bowen and Turner (1981) observed a bacterial shock when filtering material from a freshwater facility was transferred to a marine water biofilter.

In this work, two experiments were carried out in order to study 1) the effect of increasing salinity in filters started-up with fresh water and 2) the effect of TAN concentration during filter start-up on nitrification rates.

Four 3L filter prototypes were used, three of them with fresh water (F) and three with marine water (M, salinity 37%). A plastic filter medium with a specific surface of 500 m^2/m^3 was used, and added up to a specific area of 0.36 m^2 (including prototype wall surface). DO concentration was maintained over 6 mg/l with air diffusers, which maintained the medium in constant agitation. Temperature was maintained at 22ºC. Prototypes where continuously supplied during 17 weeks by a peristaltic pump with a controlled flow of fresh/marine water (5 L/day) enriched with a nutrient solution containing ammonium chloride, sodium bicarbonate, and other nutrients (Zhu and Chen, 2002). Two filters were maintained at an average concentration of 2 mg TAN/L (Higher: F1H and M1H) and two filters at 0.4 mg TAN /l (Lower: F1L and M1L).

In experiment 1, salinity was increased in filters started-up with fresh water up to 37%. The nitrification rate (R) dropped to 20% after 5 days. Nevertheless, 10 days after the salinity change, the nitrification rate was about 60% of initial value, and it reached 100% after 15 days (Figure 1).

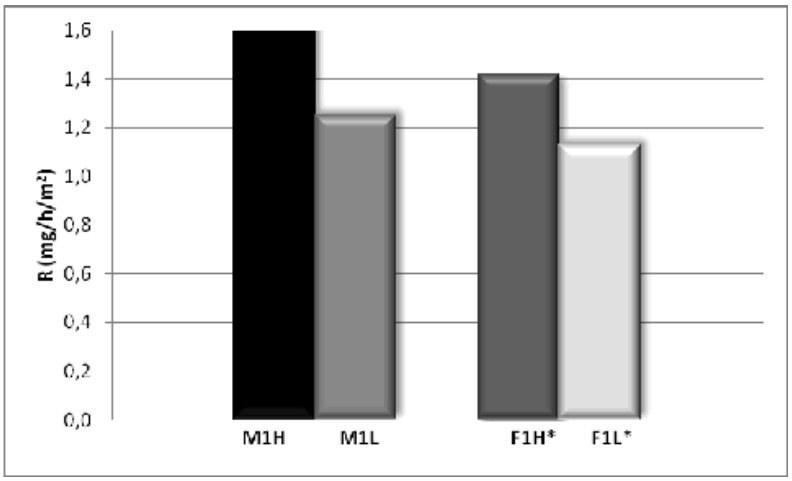

Figure 1. Nitrification rates (mg/h/m^2) in filters started-up with fresh (F) and marine (M) water, and with TAN about 2 ppm (H), and 0.4 ppm (L). In this experiment filters started-up with fresh water were adapted to 37% salinity (F1H and F1L).

In experiment 2, once the filter started-up with fresh water had been adapted to a salinity of 37%, the continuous supply of water was stopped, and filters were fed every 48 hours with a pulse of nutrient solution to reach 2 mgTAN/L. Samples were withdrawn every two hours during a period of 10 hours and nitrification rates calculated. After four weeks, the highest nitrification rate was observed in the filter started-up with marine water and higher TAN concentration (M1H), and the lowest in filters started-up with lower concentrations (F1L and M1L) (Figure 2). R values in prototypes started-up with low concentration (F1L and M1L) were about 70% than the ones obtained in prototypes started-up with higher concentrations (F1H and M1H), showing that higher TAN concentrations during starting-up period provide higher nitrification rates.

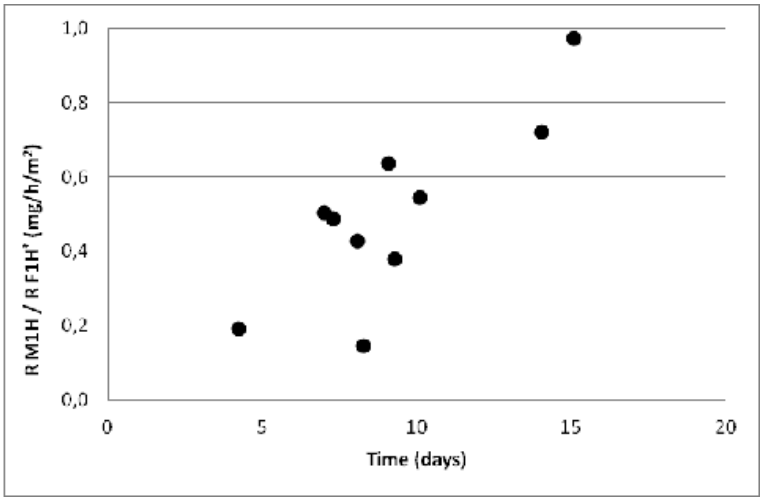

Figure 2. Evolution of nitrification rate of marine water filter (RM1H) and fresh water after salinity change (RF1H*).

Acknowledgments

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